THE CARTOUCHES OF MARS.

BY PERCIVAL LOWELL.

(*Read December 4, 1903.*)

That changes take place upon the surface of Mars is manifest to anyone who has given the planet prolonged study. Not only do the polar caps wax and wane with regular rhythm, but the dark markings with which the disk is diversified deepen in tone or fade away as the months succeed each other. The phenomena known as the "canals" are likewise subject to transformation. At times they are conspicuous; at times invisible. And what is yet more striking, each canal has its own times and seasons, its exits and its entrances. What dates the one does not date its neighbor; and still less its antipodes. The Ganges will be seen when the Titan is invisible and the Titan be evident when the Ganges can scarcely be made out.

Particular "canals" are not sole instances of such change. On occasion "canals" in whole regions appear to be blotted out. The most careful scrutiny fails to detect them, though distance be at its minimum and definition at its best. Yet before or after, under conditions much less favorable, the region stands out peopled with lines. Even the strongest and best known of these strange pencilings seem at certain seasons but wan ghosts of their usual selves. As for their more tenuous companions, it almost taxes faith to believe that they can ever have existed at all.

In order to discover what, if any, law underlay these shifting phenomena, I bethought me some two years ago of deducing from my drawings the percentage of visibility of given markings at intervals during an opposition, and of then collating the results. The great number of drawings at my disposal at once suggested this method and increased its trustworthiness, since the accuracy of a percentage heightens with the number that go to make it up.

To get the percentage I had recourse to the following plan. Taking the mean longitude of the marking from the map, I considered all the drawings which, from the longitude of their centres, might be expected to show the marking within certain zones from the central meridian, and then noted the appearance or non-appearance in each of the marking in question. Three such

zones I thought it best to take—those from the centre to 20° out on either side of it; next, those from 20° to 40° out; and last those from 40° to 60° away. This tripartite arrangement had the advantage, which indeed was the reason of its adoption, of furnishing comparison between a marking's visibility at different distances from the centre of the disk. And I may say in passing—for the subject will occupy another paper—that these relative visibilities came out in accordance with what realities on the planet's surface would show.

Were the disk always full the application would be simple and forthright. Being presented generally with a phase, certain corrections have first to be introduced. Since the illumination degrades from the point under the sun out to the terminator where it ceases altogether, a marking from this cause alone tends to disappear as it nears that boundary, and indeed within a certain distance of the night-line can never be seen at all. As such *terra non* I took empirically a zone 25° in from the terminator, such being from my observations the mean value of the semi-obliterated area. Subsequent calculation shows that this is about the value needed to equalize the chances of detection in the three pair of zones mentioned above when all the factors of position conducing to visibility are taken into account.

Convenient epochs for testing the visibility of a canal were self-offered by its several presentations. A presentation of any part of the planet is the occasion of the presentment of that part to an observer upon the earth. As Mars takes forty minutes longer to rotate than our own globe, its longitudes lose on the average 9°.6 a day in coming to the disk's meridian. In consequence of thus slowly falling behind time they complete an apparent backward revolution in about 38 days (from 37 to 41 days), since 9°.6 goes into 360° some thirty-eight times. After the lapse of this period, the two planets again show the same face to each other at the same hour. For a third of the time, therefore, the marking is well placed for observation; for the other two-thirds, it is either not to be seen because the planet is below the horizon or practically invisible because the planet is not high enough up. Thus the presentations make natural epochs for comparing a marking with itself and noting any change in aspect it may have undergone in the interval.

The data were furnished by the drawings. In the present inquiry these consisted of those made by me at the opposition of 1903

just passed, 375 complete ones in all. They date from January 21 to July 26, inclusive, and were divided by months as follows:

January	18	
February	48	
March	49	
April	70	+ 1 unfinished.
May	63	
June	70	
July	57	+ 1 unfinished.
	375	+ 2 unfinished.

Sketches of particular parts are not included in the list, as being unfit for comparison purposes.

The principle I adopted in making the drawings was that of momentary representation. My object in each was not so much an exhaustive map as an instantaneous photograph. From ten to twenty minutes only was the time allotted to each. In that period the shift of the longitudes is not enough substantially to change the degree of visibility of a marking and thus to make of the drawing a composite picture.

Eighty-five canals were examined for presence or absence in these drawings. The average number of times a canal might have been seen, had it been sufficiently conspicuous, proved to be about one hundred. The number of times it actually was seen varied with the particular canal, some canals being but rarely detected, others being almost continuously visible. From the above it follows that eight thousand five hundred separate examinations for the visibility or non-visibility of the canals had to be made in all; an undertaking of some length, but adding proportionately to the trustworthiness of the result.

For getting the percentage visibility of a canal at any presentation it seemed on the whole best to consider all three of the above pair of zones together, or, in other words, the percentage of visibility within 60° of the central meridian, limited as above described toward the terminator. Any other pair of zones might have been used with equal correctness, but the greater number of determinations got from considering all three together commended itself for its increased accuracy.

The percentages thus obtained proved sufficiently suggestive, even before any corrections had been applied. To give them,

however, their full import two corrections had in rigor to be taken into account: one for the varying distance of the planet and the other for the varying quality of the seeing. At the several presentations the planet was not at the same distance from the Earth. Now distance affects the visibility of a marking by altering its size. If the markings be large, their apparent size decreases as the square of the distance. If, as in the case with the "canals," they have length without width, we may take them as of one dimension. For beyond a certain length increase of that quantity does not seriously affect the visibility. Their width, however, although unrecognizable as such, improves their chance of being seen in the direct ratio of the planet's approach.

Now if we take the chance that a canal of twice the width of a given one is twice as likely to be made out, we may regard it as the inverse of the relative chance of commission of twice a given error of observation. We may then use the areas bounded by the curve of probability, with the width of the canals taken for abscissæ, respectively as the measures of the likelihood of detection in the two cases, since these areas include all the chances of seeing a canal of the given width. By taking the area from the central ordinate of the curve out to where that area shall equal the percentage of visibility shown at a given distance, then multiplying the ordinate there found by the inverse ratio of the given distance of the planet at the time to some fixed distance taken as standard, and then finding the area corresponding to this last ordinate, we shall get the percentage at the standard distance. It will be noted that on this principle, as the planet approaches the Earth the percentage of visibility increases gradually to unity, that is certainty of detection if the object exist at the time, since the area enclosed by the curve of probability approaches unity as the abscissa is indefinitely increased. For standard distance I took that of the planet's nearest approach to us during the opposition, when its disk subtended 14″.6 of arc. On this principle have been computed the corrections for distance.

The correction for the seeing was got in the following way. The seeing at the time of each drawing was entered in the course of observation by the side of the drawing, together with all the other marginal notes. By taking the mean of these values for all the drawings which entered into the determination of the percentage visibility of a given canal at a given presentation, we get the mean seeing under which it was observed. The correction needed in

consequence was then applied to the curves of visibility as now to be described.

Using the percentages of visibility as ordinates and the times before and after the summer solstice of the planet's northern hemisphere as abscissæ, I plotted the resulting determinations and connected the points so found by a smooth curve. These curves may be called the cartouches of the canals, since they are their distinctive sign-manuals. Each portrays on its face the varying visibility of its canal during the time that it was under observation, but it masks much more. Were the canal intrinsically unchangeable, its curve or cartouche would be a straight line, since corrections for all extrinsic causes of apparent variability have already been applied. Its cartouche would be a line parallel to the axis of abscissæ and at a distance from it proportionate to the canal's strength. On the other hand, any intrinsic change in the canal reveals itself at once by a departure from a straight line. If the canal be for any reason augmenting, its curve will rise; if it be dwindling, the curve must fall. Thus the curves or cartouches tell us not only of the apparent change in visibility but of the real change in development during examination.

On scrutinizing the cartouches the first point noticeable is the well-nigh total absence of straight lines among them. There are but two or three instances throughout the eighty-five. Thus the great majority of the canals were, during the time they were under observation, in a state of flux. For the quiescence of the remaining few we shall a little later in the paper be able to assign a probable cause.

It is next to be noticed that opposition fell not far from the centre longitudinally of the curves, and the time of the planet's nearest approach to the Earth still nearer the middle, since the first of these events happened on the 30th of March, the second on the 3d of April. The summer solstice occurred earlier, on February 28. Another epoch worthy of regard is the date of the first frost in the Arctic regions. This, as explained elsewhere (*Lowell Observatory Bulletin*, No. 1), took place 126 days after the northern summer solstice. It is indicated in the first diagram by a dotted line.

On casting one's eye down the list of cartouches arranged alphabetically, no order or law is apparent. Some canals had their minimum early, some late, according seemingly to their own personal peculiarity. But if now we seek some natural order and

take the latitude as a probable criterion, we shall suddenly be aware of a very different state of things. As the canals are not points but lines, we must select for purposes of precision some point in them as their distinctive latitude and longitude. Their mean point, or more properly the mean of all their points, has therefore been taken in each case, since it is with mean values that we find ourselves concerned. On this principle we may classify the canals by zones of latitude, advancing down the disk from the north polar cap. The canals were therefore ticketed and arranged according to the following zones:

Arctic zone,	containing the canals	whose mean	latitude	lay between	86°N.–65°N.
Sub-Arctic zone,	"	"	"	"	65°N.–50°N.
North Temperate zone,	"	"	"	"	50°N.–35°N.
North Sub-Tropic zone,	"	"	"	"	35°N.–25°N.
North Tropic zone,	"	"	"	"	25°N.–10°N.
North Equatorial zone,	"	"	"	"	10°N.–0°
South Equatorial zone,	"	"	"	"	0° –10°S.
South Tropic zone,	"	"	"	"	10°S.–25°S.
South Sub-Tropic zone,	"	"	"	"	25°S.–35°S.

86°N. was taken as starting-point because of the coming down of the north polar cap to about this latitude throughout the course of the observations. On the other hand the lowest zone extends only to 35°S., because, owing to the tilt of the north pole of the planet toward the earth, a tilt which ranged between 21°.1 and 25°.9 during the same period, the farthest observable canal south had 27°S. for its mid-point. The date at which each canal was at its minimum visibility is shown in the following list:

Time of Minimum Development of Canals.

Arctic Canals—86°–65° Lat. North.

Lat. N.	Name.	No. of Canals.	Days After Summer Solstice.		
78°	Ceraunius N.		4		
75°	Sirenius N.		6		
74°	W. Kison		0		
72°	E. Kison		0		
71°	Jaxartes			—3	
69°	Rhizius			—9	
65°	Hades		2		
		7	0		Mean 0

Sub-Arctic Canals—65°–50° Lat. North.

Lat. N.	Name.	No. of Canals.	Days After Summer Solstice.		
64°	Syrgis..............		11		
63°	Empetis.............		14		
62°	Pierius..............		18		
58°	Callirrhoe...........		10		
57°	Singames............		15		
52°	Jomanes		12		
		—	—		
		6	80		Mean 13

North Temperate Canals—50°–35° Lat. North.

49°	Arnon..............		7		
49°	Dis N..............		24		
47°	Ceraunius S.........		24		
42°	Halex..............		25		
42°	Styx		28		
42°	Udon...............		20		
36°	Sirenius Middle......		25		
		—	—		
		7	153		Mean 22

North Sub-Tropic Canals—35°–25° Lat. North.

35°	Gihon II............		59*		
34°	Isiacum..............		53*		
33°	Brontes N...........		27		
33°	Titan N.............		30		
32°	Britannia............		20		
32°	Nasamon............		43		
30°	Sitacus N...........			—9*	
28°	Dis S...............		29		
28°	Nilokeras............		35		
28°	Phison N...........		42		
27°	Euphrates N........		42		
		—	—		
		11	371		Mean 34
					Mean *33

North Tropic Canals—25°–10° Lat. North.

25°	Phrixus.............		42		
25°	Pyriphlegethon N....		34		
23°	Djihoun.............		43		
23°	Jamuna N...........		47		
23°	Libycum............		54		

* Denotes a canal *extra ordinem*, which is omitted in the starred mean.

Lat. N.	Name.	No. of Canals.	Days After Summer Solstice.	
22°	Acheron.............		35	
22°	Indus...............		64*	
22°	Nilokeras II.........		42	
21°	Lethes..............		44	
21°	Thoth		25*	
20°	Hiddekel............		55	
20°	Tamyras N..........			
19°	Oxus................		42	
19°	Uranius.............		28	
18°	Is...................		40	
17°	Erebus..............		31	
16°	Gihon I.............		50	
16°	Sitacus S............		—14*	
15°	Amenthes............		67*	
15°	Apis..		18*	
12°	Adamas..............		46	
11°	Hydaspes...........		45	
		22	838	Mean 40
				Mean *42

North Equatorial Canals—10°–0° Lat. North.

Lat. N.	Name.	No. of Canals.	Days After Summer Solstice.	
10°	Gigas N.............		46	
8°	Orcus...............		50	
7°	Phœnix..............		43	
6°	Cerberus N..........		49	
5°	Euphrates S.........		48	
5°	Phison S............		47	
4°	Chryssorrhoas........		42	
4°	Iris.................		47	
3°	Nepenthes...........		25*	
2°	Triton..............		26*	
0°	Fortunæ		46	
0°	Ganges.............		47	
		12	516	Mean 43
				Mean *47

South Equatorial Canals—0°–10° Lat. South.

Lat. S.	Name.	No. of Canals.	Days After Summer Solstice.
0°	Brontes S............		50
1°	Clitumnus...........		52
2°	Pyriphlegethon S.....		54

Lat. S.	Name.	No. of Canals.	Days After Summer Solstice.		
2°	Titan S.		60		
4°	Jamuna S.		53		
5°	Cerberus S.		54		
5°	Tartarus		63		
5°	Ulysses		71		
6°	Læstrygon		52		
7°	Cyclops		46		
8°	Orosines		58		
10°	Ausonium		66		
10°	Dosaron		56		
		13	735	Mean	57

South Tropic Canals—10°–25° Lat. South.

Lat. S.	Name.	No. of Canals.	Days After Summer Solstice.		
12°	Erymanthus		54		
12°	Gigas S.		54		
12°	Sirenius S.		63		
15°	Tithonius		73		
17°	Dargamanes		76		
17°	Elison		68		
18°	Aurum		73		
25°	Deucalion		80		
		8	541	Mean	68

South Sub-Tropic Canals—25°–35° Lat. South.

Lat. S.	Name.	No. of Canals.	Days After Summer Solstice.		
27°	Nectar	1	95	Mean	95

Of the eighty-five canals the number falling into each zone respectively was as follows:

Arctic zone	7	Canals.
Sub-Arctic zone	6	"
North Temperate zone	7	"
North Sub-Tropic zone	10	"
North Tropic zone	22	"
North Equatorial zone	12	"
South Equatorial zone	13	"
South Tropic zone	7	"
South Sub-Tropic zone	1	"
	85	

Naturally the canals on a globe are more numerous near the equa-

tor. Why the north tropic ones are more numerous than the south tropic in the list we shall see later.

Taking now the position in time of the minimum value of the curve of each canal within a given zone, and then determining the mean minimum for all the canals in that zone, we find as follows:

	Mean Minimum, in days after the Summer Solstice.	Or Exclusive of Starred Canals.
Arctic zone	0	0*
Sub Arctic zone	13	13*
North Temperate zone	22	22*
North Tropic zone	34	33*
North Sub-Tropic zone	40	42*
North Equatorial zone	43	47*
South Equatorial zone	56	56*
South Tropic zone	68	68*
South Sub-Tropic zone	95	95*

Disclosed stands a steady progression in the time of minimum development of the canals as we travel from the neighborhood of the polar cap to the equator. The orderly advance becomes even more noticeable when certain canals which appear to contain mistakes or misidentifications or mutual exchanges of visibility are eliminated. Such seem to be the Amenthes-Thoth-Nepenthes-Triton system, in which just after opposition the Thoth-Nepenthes-Triton apparently replaced the Amenthes, and then died down later as if nothing out of order had happened. The Indus and the Gihon II, or that part of the Gihon north of the Deuteronilus, are not impossibly another case of interchange. The two Sitacus and the Apis may be cases of straight li; masked in their earlier presentations by distance and unfavorable seeing. For the out-of-place development of the Isiacum, I am at a loss satisfactorily to account. Omitting the above canals from the count we get the second row of minima, which show a yet closer approach to uniformity of progression. Indeed, if we now plot the mean curves or cartouches of the mean canals at ordinal intervals corresponding to the degrees of latitude at which they occur, we shall find that a straight line will nearly pass through all the points. This is shown in Plate XV, which, based on Mercator's projection, makes of the straight line a curve slightly convex on the advancing side. But what is more remarkable, the progression does not stop at the

equator, but continues on into the planet's southern hemisphere, the sign curvature changing when it crosses the line.

Thus much of canal development the curves definitely state; but we may infer more.

Whatever constitute the canals, it is evident that their development proceeds from the pole down the disk, and, furthermore, that it advances over the surface at a fairly regular rate. It starts at the summer solstice; that is it follows the melting of the polar cap. This suggests the source of the quickening. In consequence of the water then let loose the "canals" come into being. That this can be due to a bodily transference of matter, the water in question, seems negatived by the area concerned. More darkened area is gained than is lost. But this is not an easy point to be sure of. More forthright is the negativing of such transference by the time taken. Water would make its presence felt long before the actual darkening takes place. For at the latitude of 75°, the mid-latitude of the Arctic canals, the darkening begins on the day of the summer solstice, which is considerably after the date of the most rapid melting of the cap.

But though water directly does not account for the phenomenon, water indirectly does. A quickening to growth of some kind would produce the counterpart of what we see. And these statistics furnish us with a key to its character. It is a seasonal change, but a little consideration will suffice to show us that it is quite unlike in behavior the seasonal change we know on earth.

Could we get off our earth and view it from the standpoint of space we should mark, with the advent of spring, a wave of verdure sweep over its face. If absence of cloud permitted of an unveiled view this flush of waking from its winter's sleep would be evident, and could be watched and followed as it crept higher and higher up the parallels. Starting from the equator shortly after the sun turned north, it too would travel northward toward the pole. Here, then, we should mark, much as we mark it on Mars, a wave of darkening, the blue-green of vegetation superposed upon the ochre of ground, spreading over the planet's surface; but the two would differ, the mundane and the Martian vegetal awakening, in one fundamental respect—the earthly wave travels from equator to pole; the Arean from pole to equator. Clearly the causes compelling them differ. Yet are they both seasonal in character. To what then is the difference due? To the presence or absence of moisture.

Two things are necessary to the begetting of vegetal life, the raw material and the reacting agent. Oxygen, nitrogen, water and a few salts make up the first, the sun does the second. Unless both be present the quickening into life never comes. Now the one may be there and the other not, or the other there and the one not. On earth the material including water is, except in certain destitute spots, always present; the sun it is that periodically withdraws. Observant upon the coming of the sun is then the annual quickening of vegetal life. On Mars, on the other hand, it is the water that is lacking. This we know from many other phenomena the disk presents. There is no surface water there save for what comes from the periodic thawing of the polar caps. Vegetation cannot start in any quantity until this water reaches it. Vegetal change, therefore, on Mars should start from the pole and travel equatorward. On the earth it should do the precise opposite. Now such is exactly what the curves of visibility of the canals exhibit. Timed primarily not to the coming of the sun but to the coming of the water, vegetal life there follows not the former up the latitudes but the latter down the disk. We may conclude then that the canals are strips of vegetation fed by water released from the polar cap.

The two curves of phenological quickening, the mundane and the Martian, are shown in Plates XVI and XVII. The stars mark the dead-points at successive latitudes.

We now come to a deduction from the evidence before us even more startlingly pregnant of information. Glancing at Plate XV of the mean canals, we see that the quickening proceeds rapidly and very nearly if not quite uniformly down the disk. It takes the darkening only fifty days to descend from the seventy-first parallel to the equator, a journey of some 2600 miles. This means a speed of fifty-three miles a day, or two and two-tenths miles an hour. And it does this in the face of gravity. For the spheroidal flattening of Mars, $\frac{1}{190}$ of the polar diameter, shows that the figure of the planet is in fluid equilibrium under the axial rotation. A particle of water, therefore, would know no inclination to move from where it initially was. Of its own accord it would not flow toward the equator. And as it does flow toward the equator, and with a remarkably steady progression too, the inference seems inevitable that it must be carried thither by artificial means. We are thus led to an artificial origin and maintenance of the markings called canals, and one which in essence justifies that appellative. Nor do I see any escape from the deduction.

This idea is strengthened by another circumstance connected with the development exhibited by the table. The progress of the minima, which betoken the later and later starting of the quickening down the disk, does not stop at the equator, but advances with fine indifference to that natural limit into the planet's other hemisphere. Now there the physical conditions to affect it are the precise opposite of what they were in the first or northern one. If, therefore, it were due to such cause the action should there be reversed. That it is not shows that we are here face to face with a phenomenon not simply inexplicable on natural laws but absolutely antagonistic to them.

The study here presented leads, then, to three conclusions: (1) The "canals" develop down the disk from material supplied by the melting of the polar cap; the development proceeding across the equator into the planet's other hemisphere. (2) The canals are from their behavior inferably vegetal and (3) of artificial origin.

BOSTON, December 4, 1903.

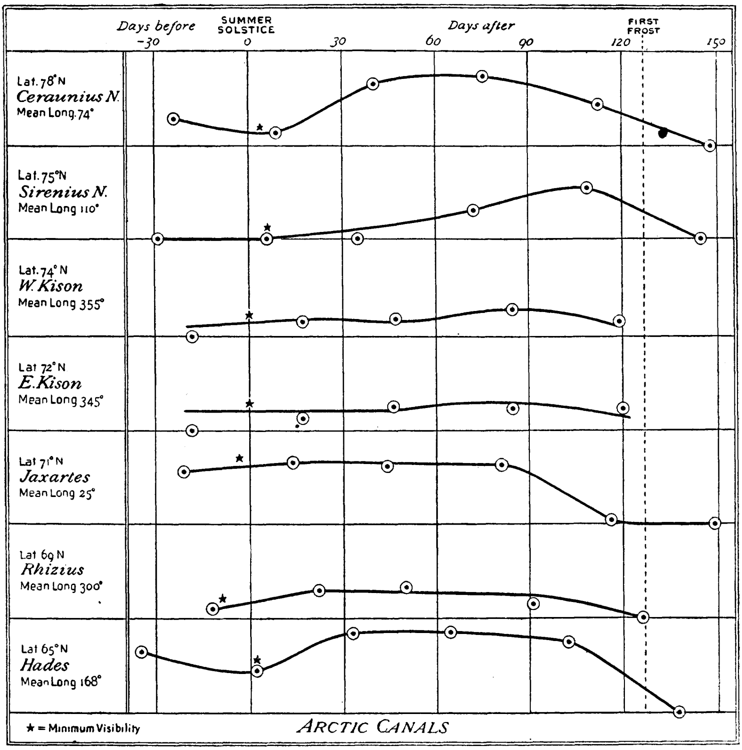

Days before
SUMMER SOLSTICE
Days after
FIRST FROST
-30
0
30
60
90
120
150
Lat. 78° N
Ceraunius N.
Mean Long. 74°
Lat. 75° N
Sirenius N.
Mean Long 110°
Lat. 74° N
W. Kison
Mean Long 355°
Lat 72° N
E. Kison
Mean Long 345°
Lat 71° N
Jaxartes
Mean Long 25°
Lat 69 N
Rhizius
Mean Long 300°
Lat 65° N
Hades
Mean Long 168°
★ = Minimum Visibility
ARCTIC CANALS

Plate I.

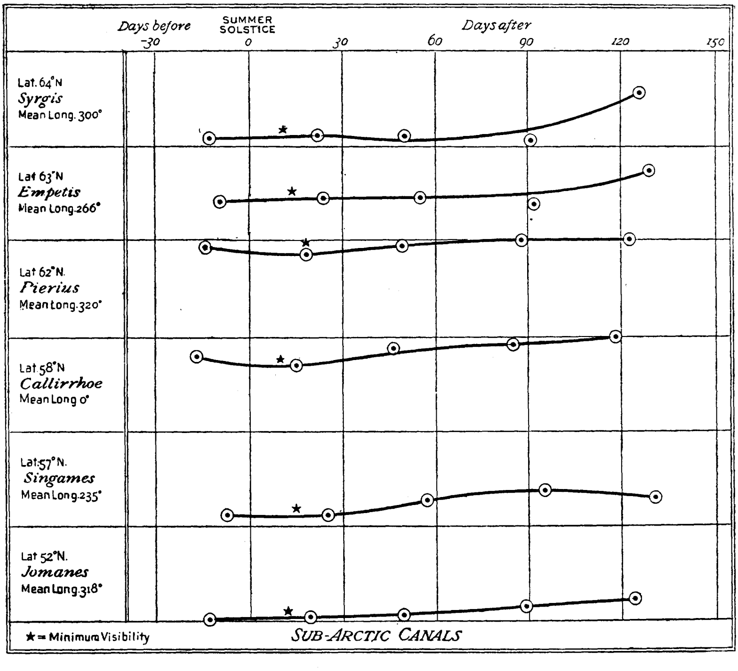

Days before
SUMMER SOLSTICE
Days after
-30
0
30
60
90
120
150
Lat. 64° N
Syrgis
Mean Long. 300°
Lat 63° N
Empetis
Mean Long. 266°
Lat 62° N.
Pierius
Mean Long. 320°
Lat. 58° N
Callirrhoe
Mean Long 0°
Lat. 57° N.
Singames
Mean Long. 235°
Lat 52° N.
Jomanes
Mean Long. 318°
★ = Minimum Visibility
SUB-ARCTIC CANALS

Plate II.

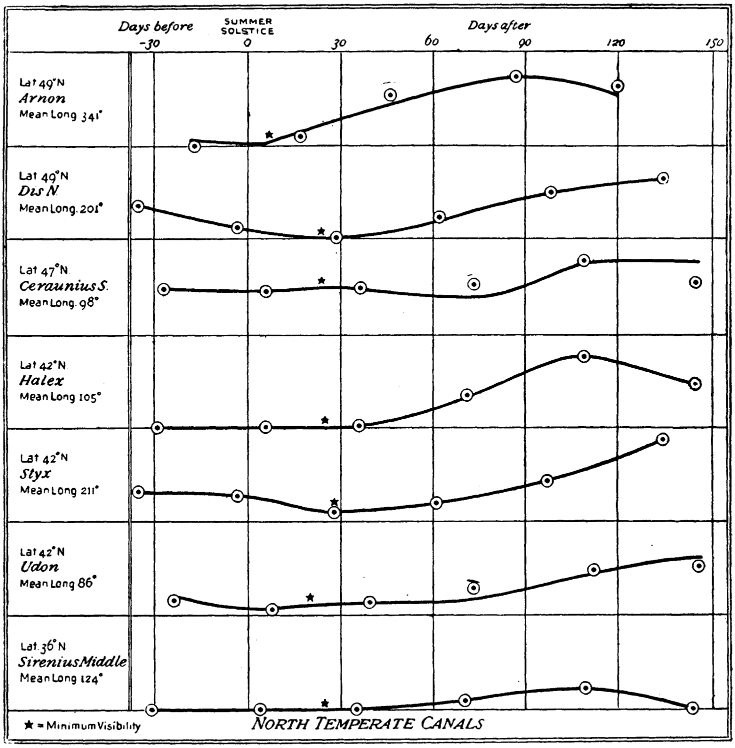

Days before
SUMMER SOLSTICE
Days after
-30
0
30
60
90
120
150
Lat 49°N
Arnon
Mean Long 341°
Lat 49°N
Dis N
Mean Long. 201°
Lat 47°N
Ceraunius S.
Mean Long. 98°
Lat 42°N
Halex
Mean Long 105°
Lat 42°N
Styx
Mean Long 211°
Lat 42°N
Udon
Mean Long 86°
Lat. 36°N
Sirenius Middle
Mean Long 124°
★ = Minimum Visibility
NORTH TEMPERATE CANALS

Plate III.

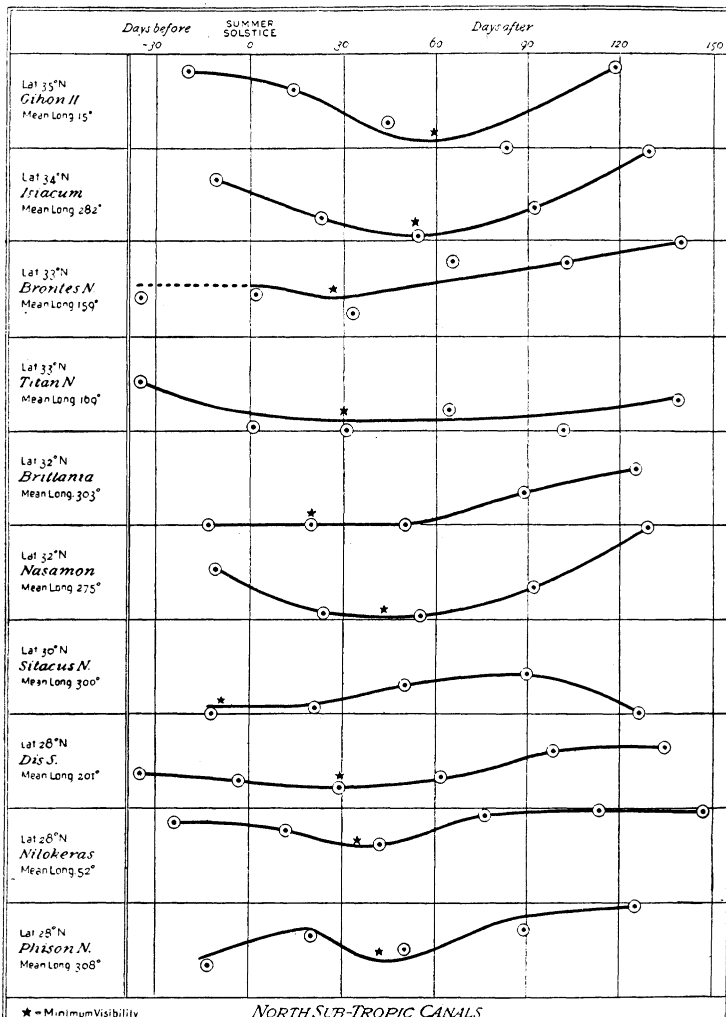


Plate IV.

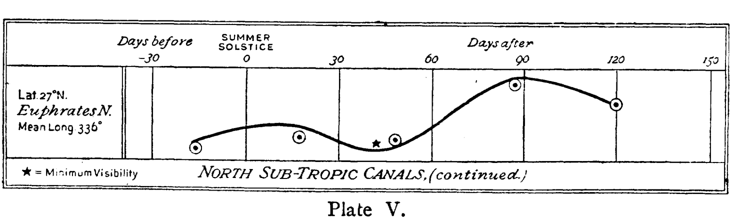


Plate V.

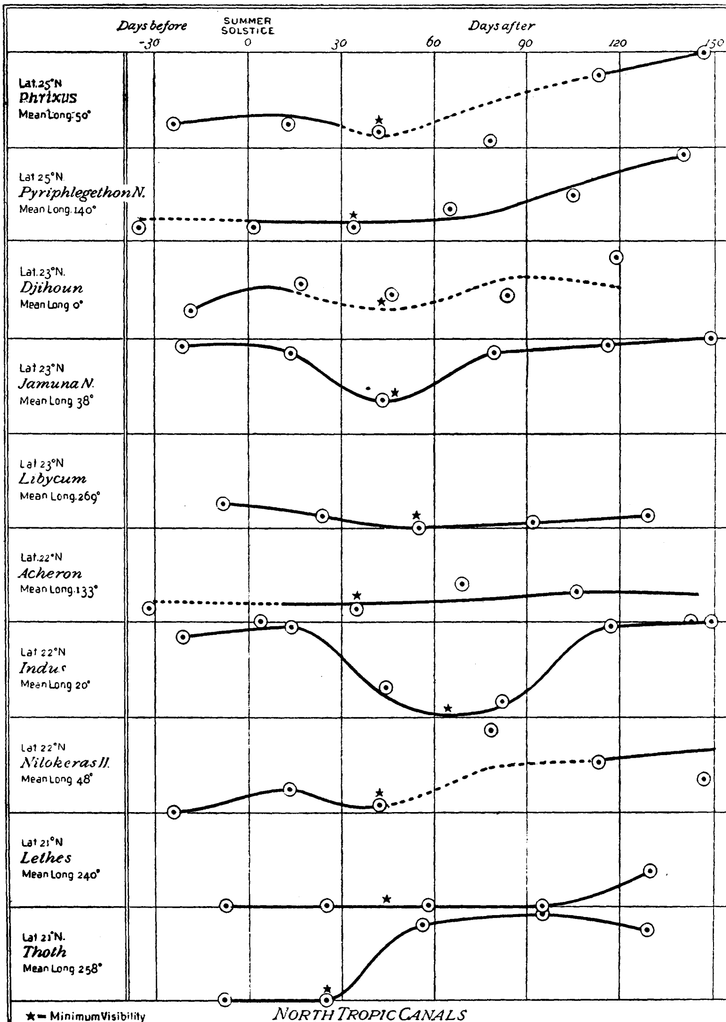


Plate VI.

The broken lines denote such portions of the curves as for certain intrinsic reasons seems the more probable.

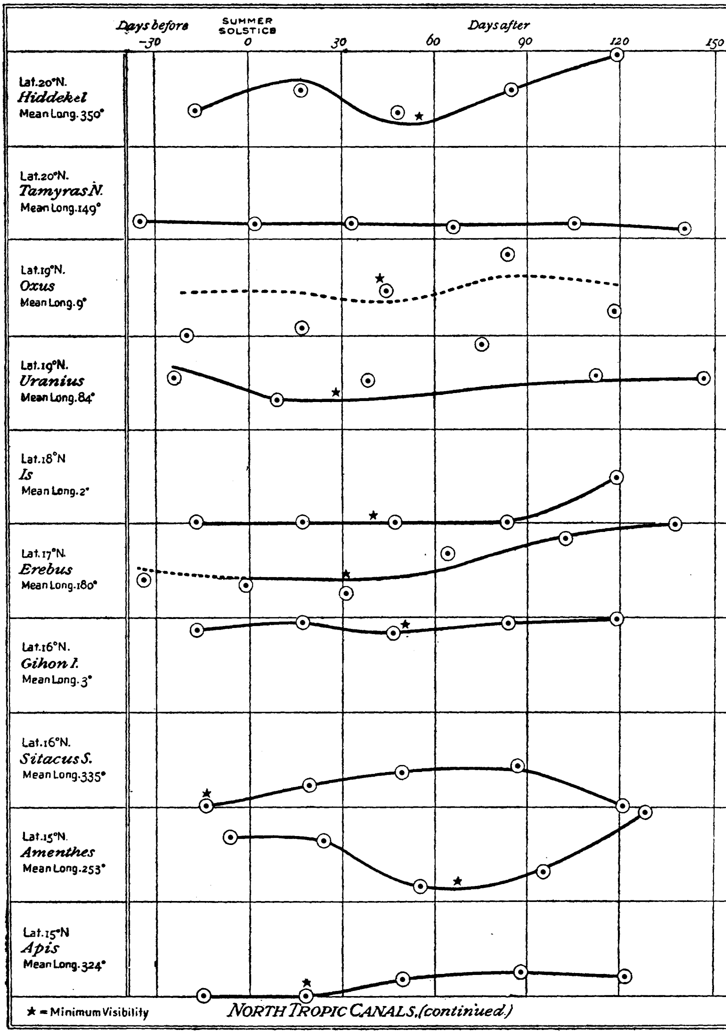


Plate VII.

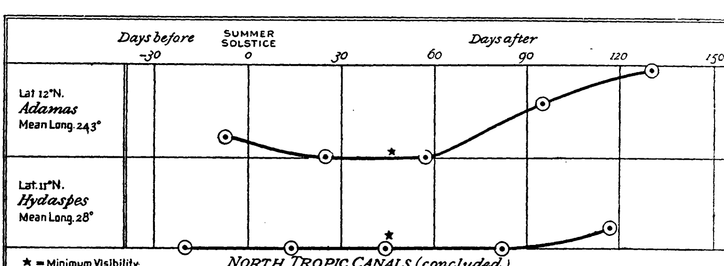


Plate VIII.

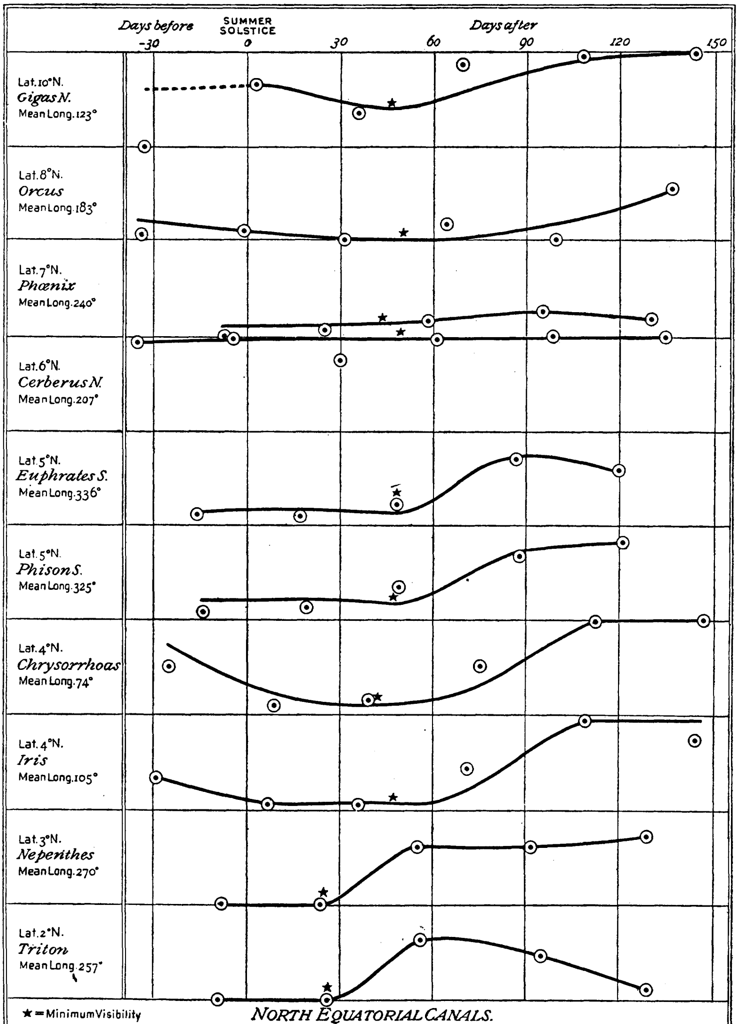


Plate IX.

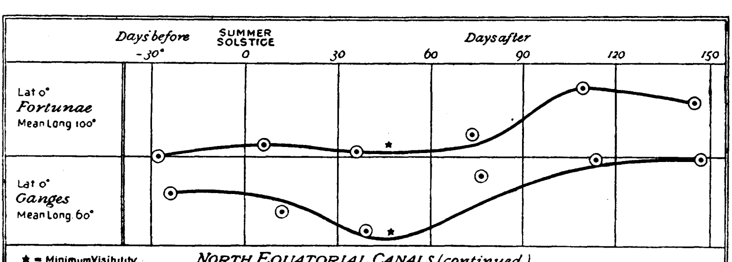
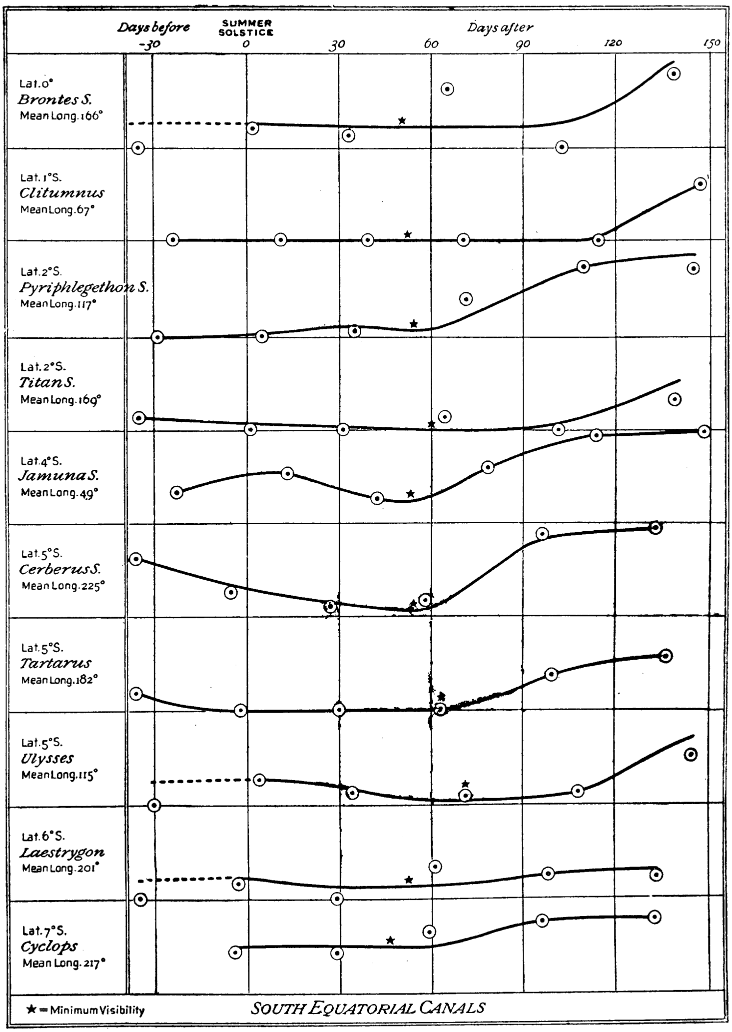


Plate X.



Days before
SUMMER SOLSTICE
Days after
-30
0
30
60
90
120
150
Lat. 0°
Brontes S.
Mean Long. 166°
Lat. 1° S.
Clitumnus
Mean Long. 67°
Lat. 2° S.
Pyriphlegethon S.
Mean Long. 117°
Lat. 2° S.
Titan S.
Mean Long. 169°
Lat. 4° S.
Jamuna S.
Mean Long. 49°
Lat. 5° S.
Cerberus S.
Mean Long. 225°
Lat. 5° S.
Tartarus
Mean Long. 182°
Lat. 5° S.
Ulysses
Mean Long. 115°
Lat. 6° S.
Laestrygon
Mean Long. 201°
Lat. 7° S.
Cyclops
Mean Long. 217°
★ = Minimum Visibility
SOUTH EQUATORIAL CANALS

Plate XI.

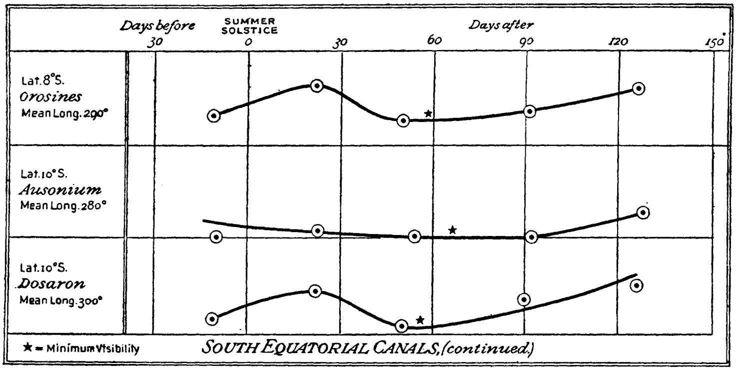


Plate XII.

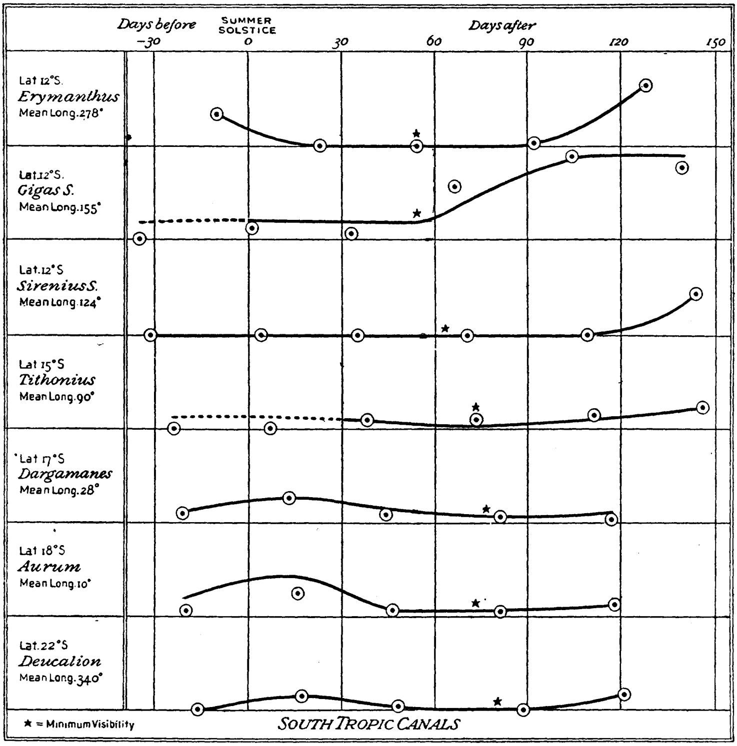


Plate XIII.

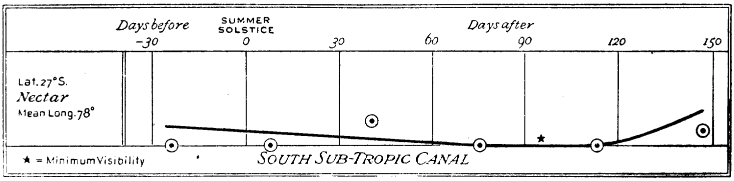


Plate XIV.

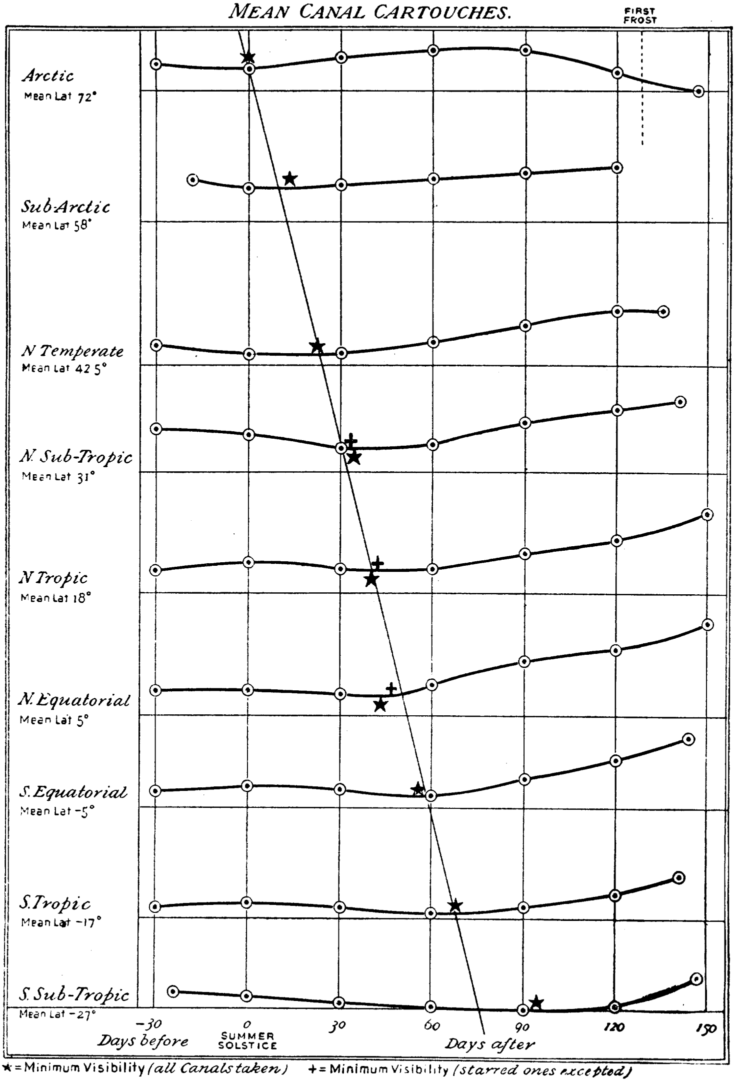


Plate XV.

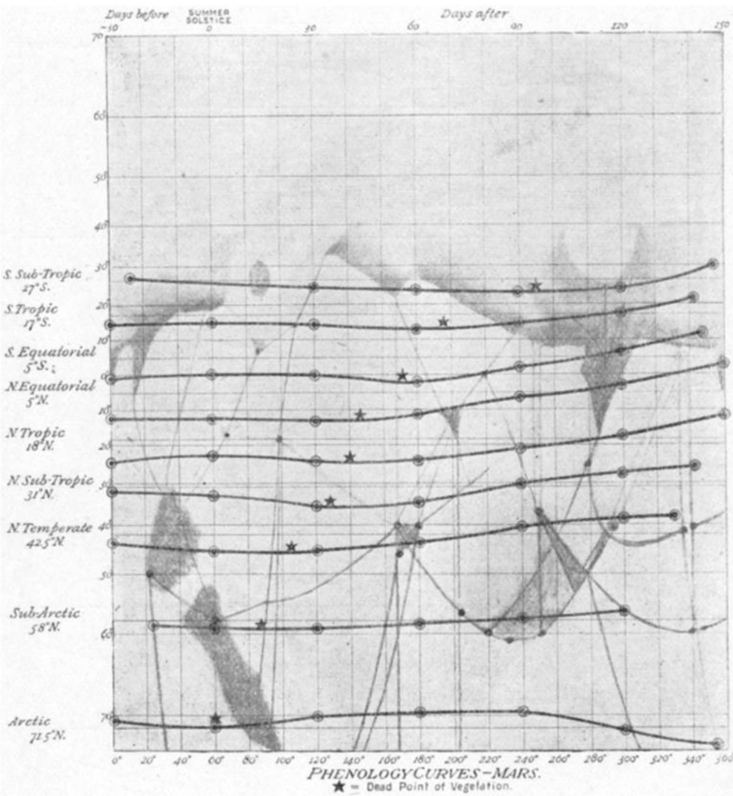

Days before
SUMMER SOLSTICE
Days after
S. Sub-Tropic 27°S.
S. Tropic 17°S.
S. Equatorial 5°S.
N. Equatorial 5°N.
N. Tropic 18°N.
N. Sub-Tropic 31°N.
N. Temperate 42.5°N.
Sub-Arctic 58°N.
Arctic 71.5°N.
PHENOLOGY CURVES—MARS.
★ = Dead Point of Vegetation.

Plate XVI.

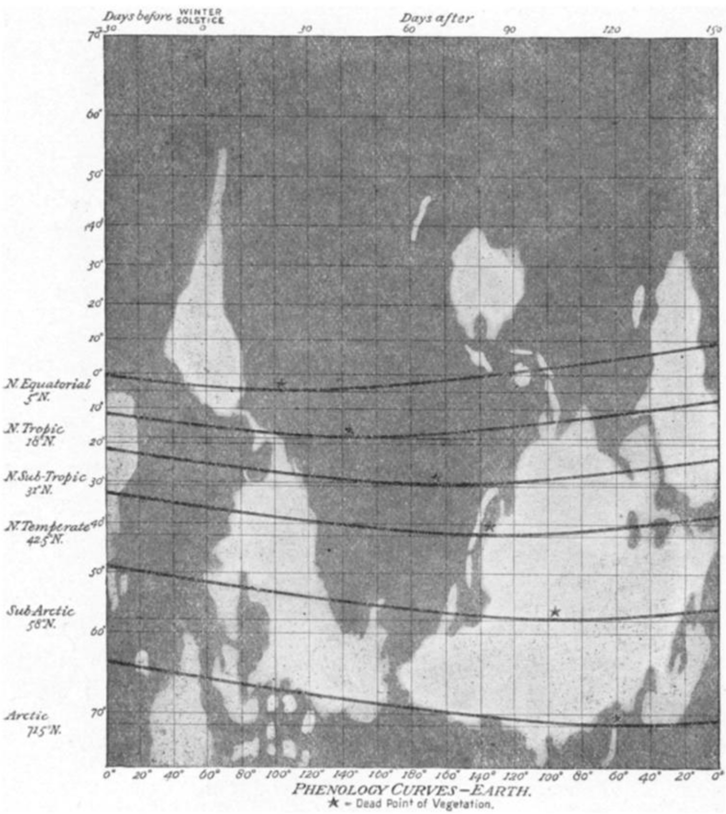

Days before WINTER SOLSTICE
Days after
N. Equatorial 5°N.
N. Tropic 18°N.
N. Sub-Tropic 31°N.
N. Temperate 42.5°N.
Sub Arctic 58°N.
Arctic 71.5°N.
PHENOLOGY CURVES—EARTH.
★ = Dead Point of Vegetation.

Plate XVII.